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ABSTRACT

The new advancement in genetics and reproductive technologies is one of the most relevant controversial topics concerning students in science education today. This study investigates the role of teachers in providing an environment for students in which they can interchange ideas and discuss ethical issues in science classrooms. This study involved the participation of 24 students from ethnically diverse backgrounds. (Contains 23 references.) (YDS)

Ethical Implications of the New Genetics: A Preliminary Study of a Pedagogical Challenge

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INTRODUCTION

The new science programme in the English national curriculum enjoins science teachers to address the ethical issues in science (DfEE/QCA 1999). It takes as unproblematic the challenges that teachers may face in exploring contemporary controversies in science. Biomedical research, for example, is developing with great rapidity and the social and ethical problems concomitant with these changes are, to some extent, unpredictable. So, how well–equipped are school science teachers to deal with topical ethical and moral questions associated with the new biomedical technologies? And what might be appropriate criteria to judge effective teaching about ethics in a science context?

Of the many controversial issues in science, advances in the genetic and reproductive technologies have a personal relevance for students. These technologies, and the underpinning science, are also important in teaching citizenship in a science context. Understanding the implications of a genetic screening programme, for example, and the possibility of having an inherited genetic condition, concerns not only the individual but also his or her family and the wider society. Decision–making is likely to involve the private morality of the concerned individuals, their specific socio–economic contexts, their personal and social relationships and their educational background. Contemporary debates about cloning human tissue and genetically modified food indicate that political decisions about approval are sensitive to public opinion. For example, the Human Genetics Commission, a non–executive advisory body to the UK government has circulated a questionnaire to the public on their attitudes towards developments in genetics.[1] The dissemination of information resulting from genetic testing has important civil rights implications. Formulating public policy and creating the conditions for democratic accountability on these issues presuppose a citizenry that has some grasp of the underlying science and an awareness of the values base. Young people entering medical vocations, the social services and teaching will need an appropriate background that enables them to deal with the many ethical, social and legal questions that will arise. The school education of an emerging lay and professional citizenry is crucial in providing a forum for rehearsal of these issues (Nuffield Council of Bioethics 1993).

1. HGC Business: Consultations. See http://www.hgc.gov.uk

A recent project, carried out by a team at the Institute of Education, University of London, for the Wellcome Trust, looked at the teaching of social and ethical aspects of developments in biomedical science (Levinson and Turner 2001). Questionnaires were sent to teachers and headteachers in 1000 schools in England and Wales followed by 111 interviews with individual teachers and groups of teachers across the curriculum. Conclusions from the research report indicate that critical thinking, participation in debate and discussion of controversial topics are far less a feature of science lessons than they are of lessons in the humanities. Science teachers tend to have an epistemological view of science as value–free. There are few instances of using expertise across the curriculum to address these issues and very few teachers, whatever their subject specialism, explicitly teach ethical principles.

While there is an emergent literature of students' attitudes towards these technologies (Hill et al 2000, Levitt and Whitelegg 1998) and students' argumentation patterns in discussing ethical issues (Ratcliffe 1997) there has been no empirical research on the teaching of these issues (Reiss 2000). Yet it is the teacher who will need sensitivity and expertise in mediating debate and possible conflict, introducing new knowledge, which is changing at an astonishing pace and will be expected to bring together different forms of enquiry – ethical and scientific. Teachers will need to be sensitive to aspects of controversy while possibly having their own conflicting thoughts and feelings; many will have had personal experiences that have a bearing on the topic being taught.

Scientific enquiry is different from ethical enquiry. Scientific enquiry is perceived to be about procedures that produce knowledge through the description and interpretation of nature whereas ethical enquiry, in the context of science, raises questions as to how we ought to act in relation to this knowledge. Procedures and concepts are distinct in these two domains although new knowledge in science may feed into the ways in which ethical questions evolve. Thus, the technology of pre–implantation diagnosis effectively offers parents the opportunity to select potential babies on their genetic characteristics. The question may arise as to whether it is acceptable to screen out potential babies who are shown to be carriers rather than sufferers of conditions such as cystic fibrosis – a question it would have been meaningless to ask before this technology became available. It may even be possible to ask if parents could select children for relatively trivial purposes, such as height and eye colour. Should individuals be allowed to make this choice? What is the boundary between acceptable and unacceptable selection? With potential treatments for many genetic conditions, should any selection be acceptable? What are the ethical grounds for decision–making on these issues?

Science specialists in England and Wales are no more trained to teach ethics than they are, say, history, geography or music. The approaches and methods for teaching science may be very different from those needed to pursue ethical questions. The ways in which science teachers approach ethical questions may depend on their perceptions of the nature of science: is the practice of science perceived as value–laden and susceptible to ethical enquiry? Or is science perceived as neutral and beyond the limits of eth-

ical questioning? Students may perceive science teachers as experts on the new genetic and reproductive technologies when the latter are only too aware of the limitations of their own knowledge. Physics and Chemistry specialists may find teaching this topic as difficult as if they were non–scientists. Finally, teachers may not have had the opportunity to rehearse their own attitudes when thinking about ethical dilemmas in biomedicine and may have had significant personal experiences, which may influence their attitudes.

An exploratory pilot study arising out of the Wellcome study has focused on developing empirical tools to study the teaching of ethical issues in controversial areas of science, with the purpose of formulating generalisable hypotheses that can be evaluated on a larger scale. While ethical ideas and perspectives can be taught in a transmissive way, any understanding of them relies on belief, experience and emotions. Indeed the immediacy of research in the new genetics is the implications for individuals, families and communities. Any educational context that presupposes skills of citizenship and the roles of citizens in a democracy is based on students rehearsing arguments and debate. Interchange of ideas in the classroom in science, and certainly ethical issues in science, should involve opportunities for talk, discussion and argument. (Newton et al 1999). This preliminary research study focuses on the role of the teacher in shaping these opportunities and in locating those tools that help to characterise the forms of discourse initiated by the teacher. The research therefore draws on ideas of discourse analysis, more specifically, the work of Edwards and Mercer (Edwards and Mercer 1987), and their debt in turn to Bruner and Vygotsky, in locating the framework within which young people at school or college are socialised into a culture of knowing.

THE CONTEXT

The medium that was chosen for the study is a one year post–16 course, *Science for Public Understanding(SPU)*. As the name of the examination course suggests, one of the important aims is to cover a range of issues which members of the public will need to understand if they are to participate in scientific and technological decision–making. (Millar 2000). It thus stands distinct from other syllabuses that have a more overt science content, and the course attracts non–science as well as science students. The module selected is based on developments and ethical dilemmas in the new genetics covering inherited diseases, antenatal screening and pre–implantation genetic diagnosis. Four two–hour sessions were observed by the researcher, a fifth session not attended by the researcher, brought together strands of the module and a previous module for examination purposes. In the first session the teacher addressed the underlying science concepts – genes, chromosomes, alleles, dominance, recessive, genetic conditions, fertilisation, (including *in vitro fertilisation*), zygote. The second session broadened out the range of genetic conditions and the need for screening. Discussion of ethical dilemmas – the focus of this study – occupied the third session and the fourth session addressed the

topic of designer babies through the video *The Gift*.[2] A wide range of strategies were used: videos, direct teaching, group discussions, true and false statements, question and answer sessions.

There are twenty four students on the course, although two did not attend any part of the module, and numbers attending the sessions varied from 22 to 12. For three of the four sessions, however, twenty or more students attended. There are ten young men in the group and fourteen young women, and in each session there were always slightly more women than men.

The teaching sessions take place in a further education (FE) college in London. A further education college is distinct from a secondary school in that it is usually larger and runs many more courses, including a mix of vocational and academic courses. Mature adults attend courses at FE colleges and often work in classes with students in the 16–19 age group. Most of the students in this group are in the 16–19 age group, although there is a Somali refugee in her early twenties who, the teacher told me, had a disabled two–year old child. The class is ethnically diverse, consisting of refugees from Afghanistan and Somalia, students from the Asian sub–continent, Afro–Caribbean students as well as white students. The class reflects the ethnic diversity of the college, and those of many schools and colleges in metropolitan areas of the UK.

THE RESEARCH STUDY

The course tutor is an experienced teacher, a chemistry specialist, who has taught SPU since the course was being developed in 1997. Researcher and teacher agreed dates for the researcher to observe the teaching of the module. In an initial interview the teacher discussed the components of the course and the educational background of the students. Most students had some qualification in science and about half were doing academic or vocational post–16 courses in science. Letters were sent to all the students on the course outlining the aims of the research project and asking for their co–operation, offering them the opportunity not to take part. No students opted out. Due to the nature of the timetabling in the college it was not possible to interview the students.

The course tutor gave students a small task, consisting of three short questions based on a popular newspaper article about designer babies, before and after the teaching of the course. The task revealed predominant student conceptions: test–tube babies are fertilised in a test–tube; test–tube babies develop and, sometimes, are born outside of the womb; pre–implantation genetic diagnosis is 'unnatural'; and designer babies are 'engineered'. Responses were coded by the researcher and blind–coded by the teacher with insignificant differences but the sample was too small to check for indicators of learning.

2. Information about this video and the company that produced it can be found at: http://www.ytouring.org.uk/

The teaching room is small, unattractive and noisy and the researcher sat in a corner, able to observe students, without being obtrusive. Audio–tapes of the teacher's talk during the lesson were taken and transcribed. Two groups of students were also recorded during group discussions and their conversations and dialogue with the teacher were also transcribed. Classroom talk was logged on a 30 second timeline and regular timed observations taken of teacher strategies, position in the classroom, gestures, activities of two randomly selected students, resources, lesson content and researcher's thoughts. Copies were taken of all paper resources used. An initial coding of lesson transcripts and interviews were carried out after the first two sessions and used for categorisation in the third and fourth sessions.

Semi–structured interviews took place with the teacher at the end of each session. These covered:

- the teacher's description of the session and perceptions of what was learned;
- responses to 'significant moments' in the lesson raised by both researcher and teacher;
- impressions of what students had learned;
- the teacher's understanding of what students knew, understood and felt before and during the session;
- challenges perceived by the teacher;
- responsibilities of the teacher in discussing particular ethical dilemmas.

RESEARCH CONTEXT

There has been much advocacy of a move towards a consideration of social and ethical issues in the science curriculum (Millar and Osborne 2000, Millar 1996, Solomon 1993, Aikenhead 1986, AAAS 1993), but such teaching programmes have to operate within the predominant discourse of classroom talk. The teacher is conceived as scaffolding the student's learning (Vygotsky 1978) so that knowledge is handed over from teacher to student (Bruner 1983). Learning, however, takes place in the context of the classroom and is mediated by both the teacher's and students' implicit understanding of the ground rules of educational discourse (Edwards and Mercer 1987). Beyond the ostensible confines of talk are the beliefs and shared understandings that both teacher and students bring to the classroom. Edwards and Mercer have produced a list of discursive devices that typify classroom discourse and the aim of this preliminary interpretive study is to capture and to problematise the nature of the interactions between teacher and student. In session 3 the teacher concentrated on teaching aspects of ethical dilemmas which contextualised the science previously taught. The analysis is divided into a. The teacher's comments at the beginning of the module; b. A discussion of three classroom interactions in session 3; and c. The teacher's comments in an interview at the end of session 3. Any names mentioned have been changed.

ANALYSIS AND FINDINGS

Pre–module interview

The teacher outlined her hopes and challenges for the topic. It should be 'interesting' and 'enjoyable' and within the SPU course it is the subject 'that gives most scope for debate, where there are really no right answers.' Her objectives were that the students would have the 'confidence to weigh up these issues', to 'improve their discussion skills' and to be 'aware of other opinions so they can freely make up their own minds.'

To achieve these objectives the teacher's strategy was to ensure the students were 'fairly clear' about the science because in issues where there is a 'fuzzy morality you have to grasp quite a bit more science to actually understand what's happening'. Given time constraints in covering the content of the module, the teacher acknowledged there was a potential tension between teaching the substantive science concepts and the time needed for open and reflective discussion of the moral and ethical issues that emerge from ethical dilemmas.

Other problems she felt she would face were that it 'would be easy to go off on a tangent and to be easily sidetracked.' The students were thought to be 'not very good at discussions'.

Teacher–student interchanges

Session 3 turned out to be the most interactive session. It was characterised by long tracts of teacher talk interspersed with interventions from students, and from one student in particular. During the first hour of the session the teacher asked one closed question but there were a series of questions, clarifications and counter–arguments from students.

Table 1. Time from beginning of session: 630s

Context	*Exchange*	*Code*	*Researcher thoughts*	*Teacher reflections from interview*
The teacher has discussed a couple where the mother is considering having an amniocentesis to test for Down's Syndrome and is mapping a scheme on the whiteboard to identify the consequences of taking different decisions. Directly before this interchange the student asks how an amniocentesis is carried out and how the test can precipitate a miscarriage.	S: So why doesn't it happen all the time then? T: Because you don't poke around inside the womb all the time. S: What I mean is it's one in one hundred (chance of miscarriage). Everytime they do that test, it's one in a hundred . . T: Yes. That's right. Well it probably depends . .some pregnancies are more . . some people seem to hold their pregnancies better than others, may be it depends on the skill of the surgeon who's doing the procedure, I honestly don't know. Most biological things are like that, aren't they, there's a random finite chance of one thing happening or the other, it's not absolute. Most biological things are like that. S: Yes, but not with the same severity. T: You know if there's flu going around in this room will half of us catch it and the other half won't? S: Yes but if we catch it we're not going to die, are we? T: No. But that's not the issue, we might do . . S: Of course it is. Obviously it's more important if someone's going to die than someone's going to catch a cold, do you know what I mean? T: Yes it is. But the question of why is not one we can answer, it's biological randomness, things are all different, and the reason we're all different is partly genetic, of course. Right. So if she does have the test . . .	Spontaneous contribution from student.	A sense of growing irritation between teacher and student. His contribution interrupts her purpose of listing the possible consequences on the board.	' there's an element of showoffness' 'you do need to move the lesson forward a bit.' 'It is difficult if someone takes a fundamental Islamic position as he does. I felt it was a discussion the others wouldn't have responded to at that point.

The student queries the consequentialist position presented by the teacher. Having an amniocentesis involves risk of a miscarriage but teacher and student interpret the concept of risk in different ways. To the student any risk is unacceptable if it endangers the life of the foetus; in the teacher's presentation the risk of miscarriage is but one factor to take into account when making a decision. Understanding the concept of risk is not a problem for the student, it is the moral framework within which he treats the nature of risk that creates the difference between his argument and the teacher's. The student's ethics are predicated on a religious basis (in this case stemming from his Islamic beliefs) so he makes a very clear distinction between 'natural' miscarriages as being due to the will of God and miscarriages resulting from human intervention as wrong. In a later group discussion on the consequences of testing for Down's Syndrome the student outlines his position at the beginning of the activity: 'From my Islamic beliefs . . . we're told that God gives us tests in different ways, yeah? If we see any little problem that we're running away from then we're not standing up to that test, even if we don't understand things now.' Differences between teacher and student in this interchange reach an impasse with the teacher affirming 'that's not the issue' and the student countering 'Of course it is'. The teacher shortly continues her narrative with a rhetorical flourish 'Right'.

Edwards and Mercer have characterised the basic I–R–F structure in classroom teaching as a commonality of all patterns of classroom discourse; there is an Initiation by the teacher, a Response by the student and Feedback by the teacher. The IRF framework can be extended, as this section of classroom exchange illustrates, to student assertion with a follow up by the teacher (Martins et al 2001). Misunderstanding generated through the student's intervention appears to be more than a breakdown in shared understanding of the implicit rules of classroom discourse. Negotiating beliefs in ethical perspectives constitutes a more formidable challenge to the teacher, as these are balanced against the content knowledge to be taught and the inclusion of all the class in the discussion. The intervention is problematically dismissed as 'showoffness' and the difficulties in discussing a fundamentalist position.

Table 2. Time from beginning of session: 840s

Context	*Exchange*	*Code*	*Researcher thoughts*
Having laid out the different options for testing or not testing for Down's Syndrome the teacher contrasts the consequentialist position compared with making decisions from absolute basic principles.	T: I think the group actually discussed this case in the first place had a completely new approach to this. They looked at absolute basic principles. They didn't look at the consequences of which is going to lead to maximum benefit or for utilitarian reasons the maximum happiness. Um S: Happiness for who? T: Well for me, it will balance out different people. It's the same balancing act that we're talking about, balancing the consequences, right? And you're right, it's a good point, you've raised a good point, it's not just a case of looking at it for you, but you've also got to consider other people in the equation as well in the particular case we're looking at, the Down's case, I think we can probably argue that the issue is really that of the two parents, but I think you're right Asif to remind me there that another factor you might well consider is the other two children.	Spontaneous intervention from student followed by teacher response	Teacher acknowledges intervention but I feel misses the point about who's happiness. Isn't student referring to the unborn baby?

This highlights a similar problem between the same student and the teacher but this time the teacher commends the validity of the student's intervention. Within twenty seconds she explicitly approves his point three times and builds it into her continuing narrative. But the irony in this exchange is that the teacher absorbs the student's comments into her utilitarian argument whereas his point comes from an absolutist worldview. The 'happiness' he is referring to is the potential happiness of the foetus who might die whereas the teacher is alluding to the happiness of all those parties other than the foetus. There is a clear misunderstanding.

Table 3. Time from beginning of session: 3720s

Context	*Exchange*	*Code*	*Researcher thoughts*	*Teacher reflections from interview*
The students are about to see a video on screening for thalassaemia in Sardinia. The teacher then opens up the question as to what would happen if someone knew they carried a gene for thalassaemia.	T: If you know you're a carrier, then what can you do about it? S1: Don't marry another carrier. T: Well that's the first one. Don't marry another carrier. Several students: How do you know?/ Don't you need to test them? T: Yes. Test them before they get married, and if they're both carriers . . . Several students: That's a bit extreme/Harsh/test them? S2 (Asif): How can you say it's harsh? You don't think having an abortion's a bit harsh? I mean you think stopping them getting married is a bit hard, but you don't think when you're killing a baby that that's a bit harsh, that's a woman's right and all the rest of it. (general disquiet, voices raised in disagreement) S3 (female): Do you choose your partner, do you go out with.. or would you marry....'Oh by the way, are you a carrier?' S2: Yeah. I would say that. S3: Oh, you would do? (hubbub of voices) S2: Looking at it in context, you're making a big deal about stopping people getting married, but you're not making a big deal about having an abortion, which is even worse. T: Well ok fair point. Can I just say that there are in many societies where marriages are arranged for all sorts of reasons. But there is no evidence that arranged marriages are any less successful than marriages based on the free choice of partners.	Teacher elicits response from students followed by spontaneous contributions.	Students feel strongly about this. Testing a partner is fraught with problems for them and they don't seem to know how to handle it. Teacher concludes talking about arranged marriages in relation to Greek Orthodox Church in London and thalassaemia present in Cypriot population. Don't think this has been presented to students yet . . non sequitur.	'As a chemistry teacher who's used to much more control because there's less to discuss. . . if you're trying to explain the bonding of benzene there's a fairly finite answer . .or even the ethics of CFCs.' ' . . problem of letting go so they can enjoy their free discussion but making sure you're managing the learning situation as a whole . . ' 'I'm not used to managing this interplay as much as, say, an English teacher (teacher of English)'.

This example is different in nature to the other two because it begins with the teacher eliciting a response from students. Identifying whether a future partner is a carrier of thalassaemia or not provokes an unruly discussion. The teacher does not take part in the interchange which revolves around the problem of directly broaching the question with a potential partner. This touches the emotions and sensitivities of young people and has raised a point of concern but the teacher quickly diverts the interchange with the potential solution of arranged marriages. Managing the issues of sensitivity and the rights of the unborn child pose serious management problems to the teacher.

Post–session interview

Many of the teacher's reflections on this session are incorporated in Tables 1 to 3. She has clearly identified problems in achieving her teaching objectives, and these problems reside mainly in controlling discussion. On prompting from the researcher to clarify problems in controlling discussion, the teacher elaborated the tension between the students enjoying their 'free discussion' and 'making sure you're managing the learning situation as a whole'. Free discussion is perceived as 'illicit' talk, attempting to remove the teacher's attention from the subject discourse. (Levinson et al 2000)

DISCUSSION

Several themes have emerged from analysis of the lesson transcripts involving classroom exchange and teacher interviews, 'control of discussion', 'teacher–student difference in belief systems', 'distinct classroom discourse between science and ethics'. The focus of this paper is not to generalise from an exploratory study but to identify those categories and questions that would characterise the qualities science teachers bring to, and the challenges they face in, areas of controversy in science, and the encouragement of participative debate and critical thinking (Rudduck 1986). The challenges identified by the teacher in 'control of discussion' are consistent with those found in the Wellcome Trust study.

> 'I remember that there was something about genetics that came up, looking at animal testing. At the end of the video a couple of kids picked up on it and there was a debate and I wasn't really involved. One child spoke vehemently against testing for cosmetics. And these sort of issues are raised in an uncontrolled way and that's part of the problem and can catch people unawares.' (Science Teacher, School A) (Levinson and Turner 2001)

It is a different proposition to manage I–R–F patterns of classroom talk of substantive science concepts compared with the ethical issues raised by students. Scott, for example, has reviewed studies of classroom discourse in science (Scott 1998), but these studies rarely transcend science concepts and procedures. As we have seen, broaching ethical issues can have an effect on the teacher's authority, which changes the power relationships and subsequently the nature of the classroom discourse. Edwards and Mercer's categories are drawn from studies with younger children. There needs to be a broader description of the cognitive and affective domains that a teacher has to contend

with in a discussion of ethical issues in a science context. These domains have been shown to include:

- substantive science concepts: e.g. 'gene', 'carrier', 'chromosome';
- nature of science: e.g. 'reductionist', 'susceptible to values', 'uncertain/certain knowledge'
- technological concepts, (know–how): e.g. procedures of an amniocentesis
- procedural concepts: e.g. 'probability', 'risk', 'screening';
- ethical concepts: 'religious beliefs' (teleological); 'acting according to strict moral principles' (deontological); 'appraising and balancing consequences' (consequentialist/utilitarian);
- feelings and emotions, sensibilities: how you and a partner might feel about being a carrier; 'killing a baby', relationships within the family;
- contextual factors: students' and teachers' beliefs and attitudes shaped by their own personal experiences.

Categorisation and analysis of classroom discourse helps to identify the interplay of teacher assumptions located in the teaching context. But there is a need for a probe that can distinguish how teachers treat different aspects of knowledge and the way teachers approach the interaction of these aspects of knowledge in the classroom. Development of a model for analysis might include the sources of teachers' knowledge, the forms of knowledge defined by Shulman (Shulman 1986) and elaborated to include teacher's knowledge of self (Turner–Bissett 1999).

It is demanding a lot from science teachers to address the ethical aspects of contemporary science issues: few teachers, whatever their specialism, can handle this area with much confidence or experience. This is not due to any inadequacy on the part of the teachers but to the complexity of the issues. These new technologies are loaded with imponderables: assessing risk, the complex nature of the scientific process (how much can teachers know whether experiments have been carried out with proper controls in place; the different assessments of the developing technology); changes in both the nature of the ethical and legal processes as the technology develops. These are difficult tasks for government appointed committees staffed by experts, let alone teachers who have pastoral, administrative and academic duties, and a varied curriculum over which they cannot possibly have full up–to–date knowledge all the time. As we have seen the teacher has to work across domains and deal with different forms of enquiry. Translating the objectives of science for public understanding – citizens' science – to the micro–processes of teaching in the classroom is deeply problematic.

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